ONTARIO WATER RESOURCES COMMISSION

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ONTARIO WATER RESOURCES COMMISSION

REPORT ON

AQUATIC WEEDS INVESTIGATIONS

OBSERVATIONS ON THE CONTROL OF
EXCESSIVE GROWTHS OF ROOTED
AQUATIC PLANTS IN SOUTHERN ONTARIO

BY

Duncan A. McLarty

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AQUATIC WEEDS INVESTIGATIONS

- 1960 -

A Report of

Observations on the Control of Excessive Growths of Rooted Aquatic Plants in Southern Ontario

Duncan A. McLarty

The
Ontario Water Resources
Commission

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SUMMARY AND RECOMMENDATIONS

1. A summary of the basic causes of excessive growths of rooted aquatic vegetation is presented and various physical, biological and chemical methods of control are discussed.
2. Aqualin, Endothol, TD-47 and Sodium Arsenite preparations were tested for the control of *Potomogeton*, *Myriophyllum*, *Ceratophyllum*, *Anacharis* and *Chara*, using one half and one acre plots.

   Aqualin was found to be equally satisfactory for the control of all species when applied at rates of 4.0 p.p.m. and more. Endothol and TD-47, although less reliable, showed considerable usefulness in the control of all species excepting *Anacharis* and *Chara*. Sodium arsenite was not effective under the conditions of testing.
3. Difficulties, associated with obtaining suitable results by the use of small, test plots, are discussed. It is noted that the levels of concentration of herbicides, found necessary for suitable results under these conditions of testing, may be considerably higher than would be demanded for total weed control over large areas.

RECOMMENDATIONS

1. In attempting to assess the effectiveness of various herbicidal chemicals for use in aquatic areas, reviews of the literature and laboratory and field experiments must be conducted with particular attention being paid to

i) the toxicity of the chemical to other forms of life and ii) the effectiveness of the chemical in the control of specific plants under specific conditions. Such information will be required for the certification of chemicals by the Commission and for the making of recommendations concerning the use of any one of many products for the control of the growth of specific aquatic weeds.

2. For testing purposes, small areas should be selected to which total control might be applied or, in larger bodies of water, large test plots, bearing a suitable relationship to the total area involved, must be employed.

INTRODUCTION

Nature and Extent of the Nuisance Problem

Over periods of geologic time the waters of lakes and ponds derive mineral elements, suitable for the nutrition of green, autotrophic plants. The process of aging is slow. Much of the mineral matter accumulated is carried off in drainage waters, but gradually the nutrients do become concentrated. By silting, the water becomes more shallow, and ultimately, the productivity of the lake or pond is increased. Additional nutrients, supplied through run-off water from rich agricultural lands and by the addition of raw or treated domestic or industrial wastes to the water courses, hasten the rate of maturation and bring closer the day when nuisance growths of aquatic vegetation effectively reduce the usefulness of the total, available surface water resources.

In Southern Ontario, natural waters are influenced, to a greater or lesser degree, by the increasing population and the consequent discharge of large amounts of mineral, plant nutrient substances. A complete and effective programme, designed to control excessive aquatic growths, would involve the introduction of suitable agricultural procedures to reduce the amount of nutrient salts in the run-off waters and, with respect to the treatment of domestic and industrial wastes, methods for the removal of nutrients before the effluent reaches the water course.

It is obvious that such comprehensive measures will not be taken in the near future. Many communities, however, have lost the use of scenic ponds and lakes for boating, swimming and fishing.

Excessive plant growth threatens the economic use of water, for industrial and municipal purposes, by contributing to odor and taste problems, by reducing flow and by adding various physical difficulties. Accumulations of dead and rotting masses of this vegetation may, indeed, produce an odor problem which depreciates the value of properties near or adjoining the waterway. In a time when the value of water as a natural resource is coming to be more fully realized, this waste of an appreciable portion of our total supply, is a matter of concern to those responsible for the regulation and control of water supplies.

At the present time, the demand for control varies depending upon the nature and the usefulness of bodies of water in any given community. In some instances, the sources for municipal water supplies are influenced, and increased cost of purification is involved. In other areas, for example, streams bearing the effluent from newly installed, efficient, sewage treatment plants become clogged with aquatic growths which are a source of embarrassment for the authorities concerned. Most of the states in the United States are reported to have regulations dealing with aquatic weed control programmes and others are studying the problem in anticipation of the day when such measures will be required. Ontario already has problems for which solutions are being demanded and, with the rising population, must also anticipate greater difficulties in the immediate future.

Methods of Control

In many area, where immediate results are required, a variety of physical, chemical and biological means of control have been suggested, promoted and practiced with varying degrees of success.

Physically, some measure of control has been achieved locally by dragging a heavy chain along the bottom of the lake, pond or stream to tear away and destroy the rooted vegetation. In some areas under-water clipping has been practiced for the clearing of drainage systems, and for the provision of better boating, swimming and fishing facilities. In each case, physical conditions must be suitable and provisions must be made for the removal of the loosened masses before they clog pumps and outlets or, by their disintegration, cause odor problems or threaten wild life. Such operations are slow, laborious, costly and futile excepting in boat slips and other restricted locations.

Where it is possible to control the water level, areas have been drained to kill vegetation by drying.

Some application of biological methods of control has been made. However, the fundamental, biological information required for such a technical procedure is not generally available at the present time. Basic research is required before practical advances may be made in this field.

Chemical means of control, despite associated problems, have made noteworthy contributions to the reduction of excessive growths of aquatic plants. In the past arsenic trioxide, in the form of sodium arsenite, has been used extensively and almost exclusively. Recently, many herbicidal chemicals are being produced and promoted. Detailed information concerning their effectiveness against various rooted aquatics under varying conditions, their toxicity to fish and other forms of life and their ecological and other side effects is required before general use may be made of them.

In this investigation, chemical means of control only were considered.

Problems Associated with Chemical Weed Control

In many areas, waters to be treated are or may be used for recreation or human consumption. Consequently, any herbicide, which may cause an enduring taste or odour to the water, is not acceptable. Toxic substances, such as sodium arsenite, must be most carefully handled and consideration must be given to the residual effects arising from the accumulation and concentration of toxic chemicals in bottom sediments and organic bodies.

The physio-chemical properties of the water concerned have a definite influence upon the effectiveness of the herbicidal chemical involved. Total hardness, pH, temperature, dilution factors, and the presence of specific mineral elements are factors which must be considered when herbicides are selected for use in any particular location. Moreover, consideration must be given to the species to be controlled. Not all plants respond to treatment with any one chemical, and usually several species occur in a problem area. A suitable herbicidal agent must be selected to provide satisfactory control. Obviously, it is not always desirable to kill all the vegetation, and selective chemicals may be used to advantage in some instances. It may be found, however, that selective control of one segment of the plant population may disrupt the ecology of the area and induce a secondary problem which is more disastrous than the first. So long as chemical and physical conditions remain suitable for plant growth, for example, one invading organism may merely be replaced by another. Oxygen depletion, odour problems and taste troubles may also be caused by the disintegrating masses of organic material left behind.

Chemical control of aquatic plant growth is, to some extent, an artificial procedure which may alleviate our problems until more satisfactory measures are available. Applied on a large scale, chemical control measures may cause far-reaching ecological problems, which must be taken into account when new, more active compounds are being considered.

Barring these difficulties, the basic requirements for a suitable aquatic herbicide may be defined. It must effectively kill the vegetation concerned when applied at rates of concentration which are not toxic to humans or wild life. It must not destroy the general ecological balance of the environment, and it must be cheap, at least in comparison with the demand for its use.

Problems Associated with New Herbicidal Chemicals

The properties and influences of the classical copper and arsenic compounds are generally understood. New compounds are coming on the market, however, which are not so well documented. Many are recommended for use in low concentrations and it is indicated that their herbicidal effectiveness is great enough to provide widespread weed control. Their over-all toxicity is often only partially known. Their total potential may not be even suspected, and investigations conducted to assess the result of their use in natural waters are needed. Many are being studied exhaustively in governmental and industrial laboratories at the present time with respect to their immediate effects and with regard to their long range influences on soil fertility, food production and human life.

As the demand for the use of herbicidal chemicals increases, and as the number of suggested compounds grows, the need for such knowledge is becoming more and more apparent. Governmental agencies, such as the Ontario Water Resources Commission, must be in a position to recommend suitable control procedures to municipalities and others which require such programmes. Moreover, they must be in a position to regulate and control the addition of all chemicals to natural waters.

METHODS OF APPLICATION AND HERBICIDES TESTED

Herbicides Tested

Aqualin, an 85% solution of acrolein, developed and supplied by the Shell Oil Company of Canada, is a chemical which had had wide application as an aquatic herbicide in irrigation ditches in the United States. More limited use has been made of it for general weed control in ponds and large lakes similar to the areas in which our tests were conducted.

Atlas A, a solution of sodium arsenite, supplied by Chipman Chemicals, was tested in several situations for the control of submerged rooted aquatics.

Endothol, the disodium salt of 3, 6 endoxohexahydrophthallic acid, supplied by Pennsault Chemicals, has been promoted and distributed as an aquatic herbicide since 1956. TD-47, an experimental derivative of the active acid involved in Endothol, was supplied in limited quantities for testing purposes.

Methods of Application

An aluminum boat, powered by an 18 horse power motor, was supplied by the Commission. It proved to be highly satisfactory for this type of work and, by means of a trailer, was easily transported to various locations where testing was conducted. A gasoline pump was used to apply herbicidal solutions through a twelve foot boom mounted on the stern of the boat. Four underwater nozzles provided for treatment of a sixteen foot swath. The various chemicals were metered into the suction side of the pump and, diluted with a large volume of lake water taken through the main intake, was distributed uniformally in the immediate vicinity of the week crop.

Crystalline materials were applied with a Cyclone Seeder.

Plots for testing were selected, when possible, in areas bearing no more than four feet of water. Aside from reducing the total volume involved, this procedure made it easier to observe the crop. For purposes of assessment of each chemical, plots bearing uniform growths of weeds, surrounded by suitable check plots, were selected. Depending upon the amount of chemical available and the particular situation, one half or one quarter acre plots were used.

In the case of Aqualin concentrations were calculated on the basis of the compound. With Endothol, TD-47 and Atlas A, calculations were on the basis of the active component in each case. Moreover, concentrations were calculated on the total volume of water to be treated.

Algal-Weed Control in Streams Receiving Sewage Wastes

One application of Endothol was made to Etobicoke Creek, at a point about 1 mile below the outfall of the sewage disposal plant at Brampton, Ontario. For this purpose, the flow was measured, using a Gurley Flow Meter and the chemical was supplied at the rate of 10 p.p.m. for a period of one hour.

TABLE I

Summary of applications of herbicides made and results obtained.

DATE	PLOT	LOCATION	WEEDS INVOLVED	HERBICIDE APPLICATION	RESULTS
June 8	1	Palgrave	P. amplifolius	Aqualin 3.0	Effect slight at 3 wks.
"	2	"	" "	" 6.0	Waterlogged, some green portions, settled on the bottom.
"	3	"	" "	" 9.0	Brown, dead, sunken -- 3 wks.
June 14	4	Belleville	Potomogeton Myriophyllum Ceratophyllum	Aqualin 3.0	Poor. Distressed fish immediately.
"	5	"	Anacharis	" 6.0	Eradication complete for 6 wks. Distressed fish apparent immediately.
June 15	6	Trenton	Myriophyllum Ceratophyllum	Aqualin 6.0	*90% eradication in 2 wks. Some regrowth in 5 wks.
"	7	"	"	TD-47L 1.2	Complete eradication. Clear for 5 wks. Distressed fish apparent immediately.
"	8	"	"	TD-47L 0.2	90% eradication. Some regrowth in 5 wks. Distressed fish apparent immediately.
"	9	"	"	Endothol 1.0	Clear excepting SE corner. Regrowth in 5 wks.
"	10	"	"	Endothol 5.0	Clear excepting SE corner. Regrowth in 5 wks.
"	11	"	"	TD-47G 0.1	Clear excepting SE corner. Regrowth in 5 wks.
"	12	"	"	TD-47G 0.5	Complete eradication. Clear after 5 wks.
June 30	13	Acton	Myriophyllum Ceratophyllum	TD-47G 0.5	No result.
"	14	"	Potomogeton Anacharis	Endothol 1.0	Temporary partial kill.
"	15	"	Chara	Endothol 3.0	Temporary partial kill.

Table I cont'd

June 30	16	Acton	Myriophyllum Ceratophyllum Potomogeton Anacharis Chara	Atlas A	5.0	No result.
July 12	17	Etobicoke Creek	Filamentous green algae	Endothol	10.0	Evident in 3 days. Cleared for 5 miles by 7 days.
July 14	18	Acton	Myriophyllum Ceratophyllum Potomogeton	Aqualin	4.0	Tall weeds down first followed by bottom forms. Seventh week - clear.
"	19	"	Anacharis Chara	Aqualin	7.0	Bottom clear - two weeks.
July 19	20	Acton	Myriophyllum Ceratophyllum Potomogeton Anacharis Chara	TD-47G	1.0	All but Anacharis. Chara removed in 5 wks.
"	21	"		TD-47L	1.0	Similar to but not quite as effective as granules
"	22	"		Endothol	4.0	Marked reduction but Anacharis, Chara remaine
"	23	"		Atlas A	10.0	Some slight reduction of all species.
July 29	24	Trenton	Myriophyllum Ceratophyllum	Aqualin	3.0	Massive reduction in 2 weeks.
"	25	"	"	Aqualin	6.0	Defoliation, stem burning in all plots. Definite boundary to plots visible. Some regrowth in 6 wks.
"	26	"	"	Aqualin	9.0	
Aug. 4	27	Trenton	Myriophyllum Ceratophyllum	Endothol	5.0	No result.
"	28	"	"	TD-47L	3.0	50% reduction.
"	29	"	"	TD-47G	1.5	No result.
Sept. 7	30	Bridgeport	Myriophyllum Ceratophyllum Anacharis Hydrodictyon Spirogyra Potomogeton	Aqualin	7.5	Clear in one week.

* These results are based on the assumption that the test areas were actually bearing uniform, heavy weed growths at the time of treatment.

G = Granular

L = Liquid

OBSERVATIONS

In general, the best and most satisfactory results and observations were obtained in smaller bodies of water where currents and other disturbances were not present to dilute the chemical and influence the results. In most of these cases, a relatively large proportion of the area involved received treatment.

Plots 1 - 3, in a private forty acre lake near Palgrave bore heavy crops of P. *amplifolius*. Aqualin was effective at 3.0 p.p.m. but at 6.0 and 9.0 p.p.m. the growth was broken down and totally destroyed after three weeks. In this connection it was observed, however, that a widespread deterioration of the growth had occurred generally throughout the portion of the lake treated. A second area of the lake, connected to the first by a narrows, showed growth which was characteristically poor in colour but which was crisp and brittle. Other chemicals had been applied to other small plots as well and it was apparent, from surface and aerial observations conducted by the officers of the Metropolitan Toronto and Region Conservation Authority, that diffusion of the herbicides had occurred and that the individual plots were not discernible. Perhaps, in this location, the effectiveness of some or all of the test chemicals was much greater than calculated.

Plots 4 and 5 were located at the inner end of a boat basin in Belleville. Weeds were well established and boating was hindered by the growth at the time of application. Three p.p.m. of Aqualin was not effective. Although some killing resulted, the borders of the plot and the general area of influence were not easily recognizable. The 6 p.p.m. plot was cleared of all weeds, however, and remained so for at least six weeks before regrowth was observed.

Plots 6 - 12 were located at the air base at Trenton Royal Canadian Air Force station where weed growths made the movement of float aircraft and boats difficult. Mechanical removal of weeds is currently used to keep the lanes open.

When these plots were established, stormy weather made observations difficult and in many areas, deep water and high turbidity reduced the visibility of the bottom. Areas reported to be heavy producers were selected by Air Force personnel and the treatments, listed in Table I, were applied. It is with some reserve, therefore, that the results are given. Since the weeds were not reaching the surface at the time and were not actually observed. For a period of five weeks, after which regrowth was occurring, Aqualin at 6.0 ppm, and TD-47 liquid formulation at 0.2 and 1.2 ppm gave good control. TD-47 granules applied at the rate of 0.5 ppm gave similar satisfactory results while 0.1 ppm was proportionately less effective. Endothol, 1.0 and 5.0 ppm, also gave quite satisfactory results but growth did persist in the southeasterly portions of the plots, and when compared with the overall distribution of growth in the area, it was possible that control was natural rather than induced by treatment.

During the treatment of Plots 4 and 5 with Aqualin, small fish were noted, almost immediately, at the surface in distress. When the area was observed several hours later it was apparent that many of these had recovered. A significant number of fish, mostly pumpkin seeds Lepomis gibbosus, however, were dead in the vicinity of the plots. In a similar fashion, small fish, mostly bull heads Ameiurus nebulosys were immediately affected with TD-47 was applied to plots 7 and 8. While no dead fish were later observed, gulls were observed feeding on the fish while they were on the surface.

In plots 13 - 16, in an artificial lake in Acton, TD-47 granules did not control Myriophyllum and Ceratophyllum, as it appeared to do at Trenton. Atlas A similarly had no influence while Endothol, at 1.0 and 3.0 ppm, gave only a partial, temporary result.

These results, with respect to TD-47 and Endothol, seem to be supported by those recorded by others for the same products. In private communications it has been learned that, under varying circumstances, the degree of control achieved with respect to the same weeds may vary widely.

An isolated experiment (plot 17) relating to control of algal growths and weeds in streams receiving sewage effluent, was interesting. At the outfall, where the effluent flowed, there was a sharp line at which growth was entirely removed and, for approximately one mile downstream no growth occurred. At the Dixie Road, however, heavy growth of filamentous green algae was observed and Endothol was applied at this point at the rate of 10.0 ppm for one hour. After one week the stream was clear of algal growth to a point beyond the #401 Highway, approximately 5 miles below the point of treatment.

With respect to such infestations of streams, it has been often observed that such conditions are evanescent. Relatively heavy growths may occur for a time and then break down naturally. For this reason, subsequent tests on the Etobicoke Creek and on other streams observed, were not possible at the times available for tests.

Plots 18 and 19, to which 4.0 and 7.0 ppm of Aqualin were applied, gave most satisfactory results. The tall forms were reduced rapidly. Anacharis was, however, quite resistant and Chara, which covered the entire bottoms of the plots, was most resistant of all. In the 4.0 ppm plot the bottom was clear in 7 weeks while 7.0 ppm killed all the vegetation in a two week period.

In plots 20 and 21, TD-47, both granular and liquid formulations, gave quite satisfactory results at 1.0 ppm concentration. The Myriophyllum, Ceratophyllum and Potomogeton were removed and inhibited for a seven week period. Only the Anacharis and Chara, both of which are bottom growths which rarely reach the surface, was resistant to the chemical. Endothol, applied at the rate of 4.0 ppm (plot 22), was much less effective against all forms and had no effect on Anacharis and Chara, forms known to be resistant to the chemical. Atlas A (plot 23) provided only a limited reduction in Myriophyllum, Ceratophyllum and Potomogeton.

With respect to plots 20 - 23, it should be recorded that growth was extremely heavy, making boating almost impossible. After the applications were made it was possible to move about quite readily even in the plots where minimal results were recognized. Where positive control was not brought about, a marked improvement in conditions was achieved. With respect to the concentrations used, moreover, consideration must be given to the great mass of organic matter contained in the treated areas.

Somewhat similar results were obtained for plots 24 - 26 which were located in Lake Ontario at Trenton and which were treated with various concentrations on July 20. The beds were covered on the surface and operation of the boat was difficult. Diffusion of the chemical apparently occurred and the vicinity of the plots, treated with 3, 6 and 9 ppm respectively, had a uniform appearance after two weeks. A definite boundary was apparent, however, on the westerly side of the treated area where weeds remained in the untreated zone. A remarkable reduction in the massive growth of Myriophyllum and Ceratophyllum was accomplished. After two weeks, boating in the plots was readily accomplished and the remaining specimens, probably 25% of the original crop, was defoliated and the stems had many, brown, necrotic areas. After six weeks, however, regrowth was well advanced.

The Trenton plots were located in a large, open bay on the border of Lake Ontario. The consequent mixing and dilution associated with a large body of water must be taken into consideration in assessing the results of control experiments.

Plots 27 - 29, bore heavy growths when applications of herbicides were made. One month after treatment, plots treated with Endothol (5.0 ppm) and granular TD-47 (1.5 ppm) showed no result. TD-47 liquid, applied at the rate of 3.0 ppm brought about a 50% reduction in the crop.

Plot 30, a one half acre plot treated in an artificial lake at Bridgeport with an estimated water surface of 5 - 8 acres, gave very positive results. For the most part the lake was shallow, heavily silted and heavily overgrown with Myriophyllum, Ceratophyllum, Potomogeton, Anacharis, to the point where boating was accomplished with great difficulty. In addition, the unsightly appearance of the area was contributed to by large mats of Hydrodictyon, Spirogyra any many other filamentous green algae.

With great difficulty, one plot only was treated with 7.5 ppm of Aqualin. In approximately one week the lake was cleared of all detectable vegetation. The mats of algae were removed and visible, nuisance growths of rooted aquatics were eradicated. Flow in the lake was almost negligible. The treated area was almost in the middle of the Y-shaped body of water and the control extended throughout the entire lake. Very little flow was occurring at the time. This was a very impressive demonstration of the ability of herbicidal chemicals to provide for the solution of serious weed problems in small bodies of water.

DISCUSSION

Effectiveness of Various Herbicidal Chemicals

1. Aqualin

When applied at the rate of 4.0 ppm or more, Aqualin was generally effective against species of Potomogeton, Myriophyllum, Ceratophyllum, Anacharis, and Chara. In large bodies of water, however, the effectiveness of the chemical in small test plots is difficult to assess at times due to dispersal and dilution by the action of the water.

In smaller bodies of water a more positive result is possible. In plots 18 and 19, in a small artificial lake at Acton, complete control of all species was achieved. In a similar situation at Bridgeport (plot 30), an application of Aqualin at the rate of 7.5 ppm for one acre gave complete control of rooted aquatics and algal species present, not only in the treated area but in the entire lake. Very little flow was observed in the lake at the time of treatment and it is apparent that the chemical, in this situation, was much more effective than had been anticipated.

Aqualin has been found to be more effective than any of the other chemicals tested and it provided for the control of the greatest number of species encountered. It is, however, toxic to fish and should not be used in areas where toxicity to fish and other organisms is an important factor.

2. Endothol

Endothol was not as effective as Aqualin as an herbicide in our tests. Consideration should be given, however, to the generally lower rates of application which were used. Under the difficult circumstances presented at Trenton in Lake Ontario, fairly satisfactory results were obtained in June (plots 9 and 10) but in August, under similar circumstances, poor results were obtained. At Acton in June (plots 14 and 15) Endothol produced little killing but in July (plot 22) a satisfactory eradication of *Myriophyllum* and *Ceratophyllum* occurred when 4.0 ppm were applied. *Anacharis* and *Chara* were not influenced.

These results seem to be similar to those reported in private communications Pennsalt field men. Such variation in results has been encountered elsewhere with Endothol as an herbicide and no satisfactory explanation is available. In a similar fashion, Endothol has been reported to be ineffective so far as *Anacharis* and *Chara* are concerned.

A single application of Endothol was made for the control of aquatic growths in a stream which was influenced by sewage effluents. The chemical was applied at the rate of 10.0 ppm for one hour. As a result of this treatment the stream bed was cleared of all excessive algal growth for a distance of five miles. Although no firm conclusions may be drawn from this single experiment, it seems that suitable control may be achieved locally by this means.

3. TD-47

This experimental chemical proved to be more effective than Endothol and at lower concentrations. Similarly, however, uniformally good results were not obtained. In some instances the granular preparation appeared to give better results than the liquid formulation. As might be expected from the Endothol applications, TD-47 was not effective in the control of *Anacharis* or *Chara*. At Trenton, apparently good control of *Myriophyllum* and *Ceratophyllum* was obtained with both granular and liquid preparations applied at rates varying from 0.1 to 1.2 ppm in June. Later in the season, the chemical was not so effective. At Acton applications of both granules and liquid gave good control of *Myriophyllum* and *Ceratophyllum* when applications of 1.0 ppm or more were made.

4. Atlas A

Only two applications of Atlas A were made during the investigations. When applied at the rate of 5.0 ppm no result was obtained at Acton (plot 16). On plot 23, 10.0 ppm was applied but only a slight reduction in growth of all species was observed with no eradication and no significant improvement of the situation resulting.

It should be noted, however, that Arsenic trioxide has been used for many years for the control of submerged rooted aquatics. In Wisconsin, for example, 186,000 lbs. of this arsenical was used for this purpose in 1959. Although certain species are known to be resistant and the possibility of accumulating toxic concentrations of arsenic in bottom muds and in various organisms is recognized, serious difficulties have not been encountered in actual practice. In terms of cost and efficiency, sodium arsenite warrants continued consideration as an aquatic herbicide.

Other Available Aquatic Herbicides

The aquatic herbicides which have been discussed here represent only a sampling from the growing list of chemicals which are presently being developed and promoted for the control of various aquatic growths. For the sake of completion, some additional compounds are mentioned for which claims have been made in the literature.

Two 4-D granules (20% active Iso-octyle ester), applied at rates ranging from 100 to 200 pounds per acre has been reported as effective against species of Potomogeton, Myriophyllum, Ceratophyllum and Anacharis. Benoclor 3C, a chlorinated hydrocarbon, has been suggested for general control of rooted aquatic growths in areas where toxicity to other forms of live may be tolerated. Simazine, widely used in the control of crop weeds, has also been suggested for use in aquatic habitats, although its general effectiveness has not been widely demonstrated. Kuron and Silvex, propionic acid compounds, have been reported in the literature as having quite a good deal of promise as generally effective aquatic herbicides.

Species variations, seasonal conditions and ecological considerations must be taken into account in order to adapt the proper chemical to the existing situation and to achieve control.

Toxicity to Fish

When Aqualin was applied at Belleville, at 3 and 6.0 ppm, small fish were brought to the surface almost immediately. Although some were killed, a good number apparently recovered. When applications of 4.0 and 7.0 ppm of Aqualin were made to test plots in Acton, however, many schools of small fish were observed in the weed beds but none were caused to come to the surface and none were later observed. Five days later, mature pike were reported dead in the vicinity of the treated plots but no reasonable connection could be made between this fish kill and the treatment procedure.

When TD-47 was applied to test plots in Lake Ontario on June 15, 1960, small fish were again noted in distress at the surface of the water very soon after application was begun. None, apparently, were killed. When some slight amount of TD-47 was spilled through the floor of a boat dock, snails, which had been attached to the bottom of the float, almost immediately were dislodged and killed. Some thought has been given, subsequently, to the use of this product for the control of problems in which snails are involved.

In selecting a suitable aquatic herbicide, attention must obviously be given to the toxicity of the chemical to other forms of life. When the concentration which is effective for weed control closely approximates the lethal concentration for other forms of life, the use of such a chemical must be considered only in suitable, selected locations.

Toxicity to Humans

With respect to all of the chemicals dealt with in this report some information is available from the Manufacturers concerning mammalian toxicity. The concentrations recommended for weed control are thought to be well below mammalian toxicity levels. However, the procedures specified by the Manufacturer must be strictly observed.

All herbicidal chemicals, with the possible exception of 2, 4-D, are potentially dangerous to the operator. Aqualin presents particular problems since it is a lachrymatory compound, similar to tear gas, and must, consequently, be dealt with in a cloud system.

Duration of Influence

In selecting an economic and effective herbicide for use in aquatic habitats the rapidity of action of the chemical, the concentration required and the frequency of application demanded must be taken into consideration along with the initial cost of the preparation.

In the open waters of Lake Ontario, regrowth was observed, following applications of all chemicals tested, after five to six weeks. In more confined waters, such as in the Acton lake, regrowth commonly occurred after seven weeks, and in the case of plots treated with Aqualin at this location, the beds remained clear up to our last observation, a period of eight weeks.

It is probable that an effective treatment early in the season would prevent excessive growths from occurring during the balance of that season.

Problems Associated with Testing -- Procedures.

It is quite apparent that satisfactory, uniform and reproduceable results cannot be obtained when small plots are treated in large bodies of water. Dilution of the test chemical by diffusion and by wave and current action is certain to occur under such circumstances to varying degrees. The results, consequently, will vary accordingly and often may be quite misleading.

To properly assess the effectiveness of any aquatic herbicidal chemical the plots must be enclosed, where possible, to control the experiment and to produce reliable and reproduceable results. Where, as in large bodies of water, this is not possible, large areas must be treated to minimize the dilution factor and to enable the investigator to satisfactorily interpret the results.

When only a small portion of a larger area is being treated, higher concentrations of the chemical must be applied if a result is to be obtained. This concentration cannot be taken as a guide when large-scale operations are planned. The concentrations noted here for effective treatment of small test plots are probably unrealistically high in terms of what would be required for the total treatment of large areas.

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